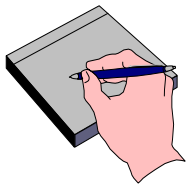
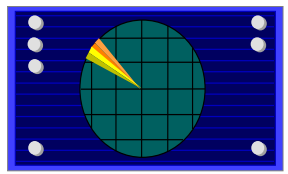
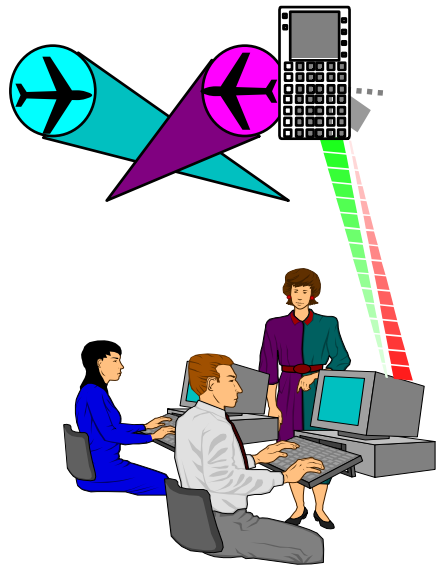
Intent
or
How Do We Get To Trajectory-Based Air Traffic Control and Management?

Mike Harrison
Aviation Management Associates
NAS Evangelist
3rd ICNS Technologies
Conference and Workshop
May 19, 2003

Evolution of ATC/ATM

Past	*Present*	*Future*
Procedural Separation	**Radar Separation**	**Trajectory Separation**
		
Estimate current & future aircraft positions	**Know current & estimate future aircraft position**	**Know current and future positions**

Immediate Problems

- **Knowing when to stop the research and start development**
- **Influencing ERAM to accept intent**
- **Making a commitment to standards for the message**
- **Working the aircraft piece before the pipe is installed**
- **Transition strategy lacking**
- **Leadership to define funding**

Some Definitions…

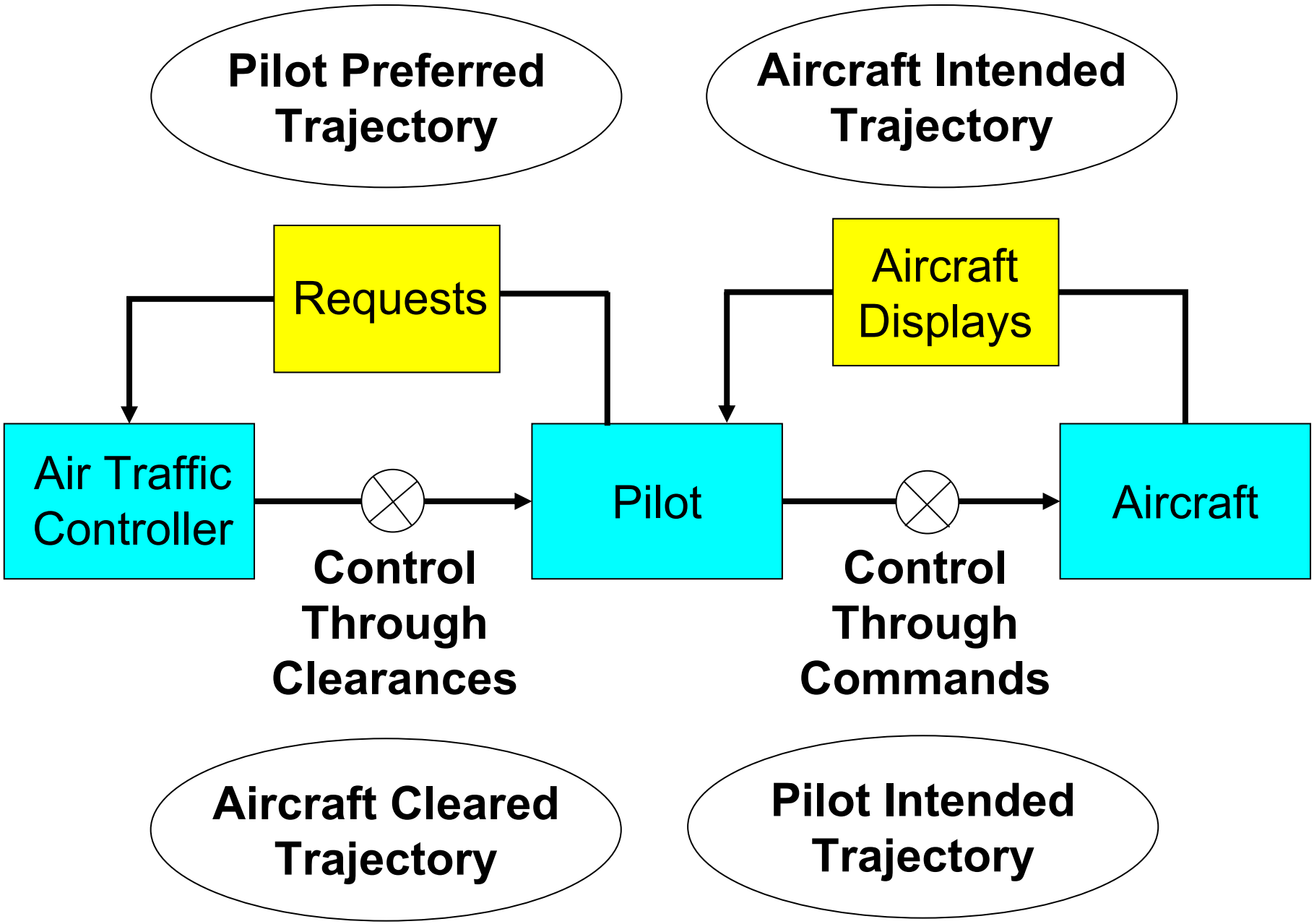
Aircraft State - Current reported 4-D status

Aircraft Intent - information on the planned future aircraft behavior that can be obtained from the aircraft systems

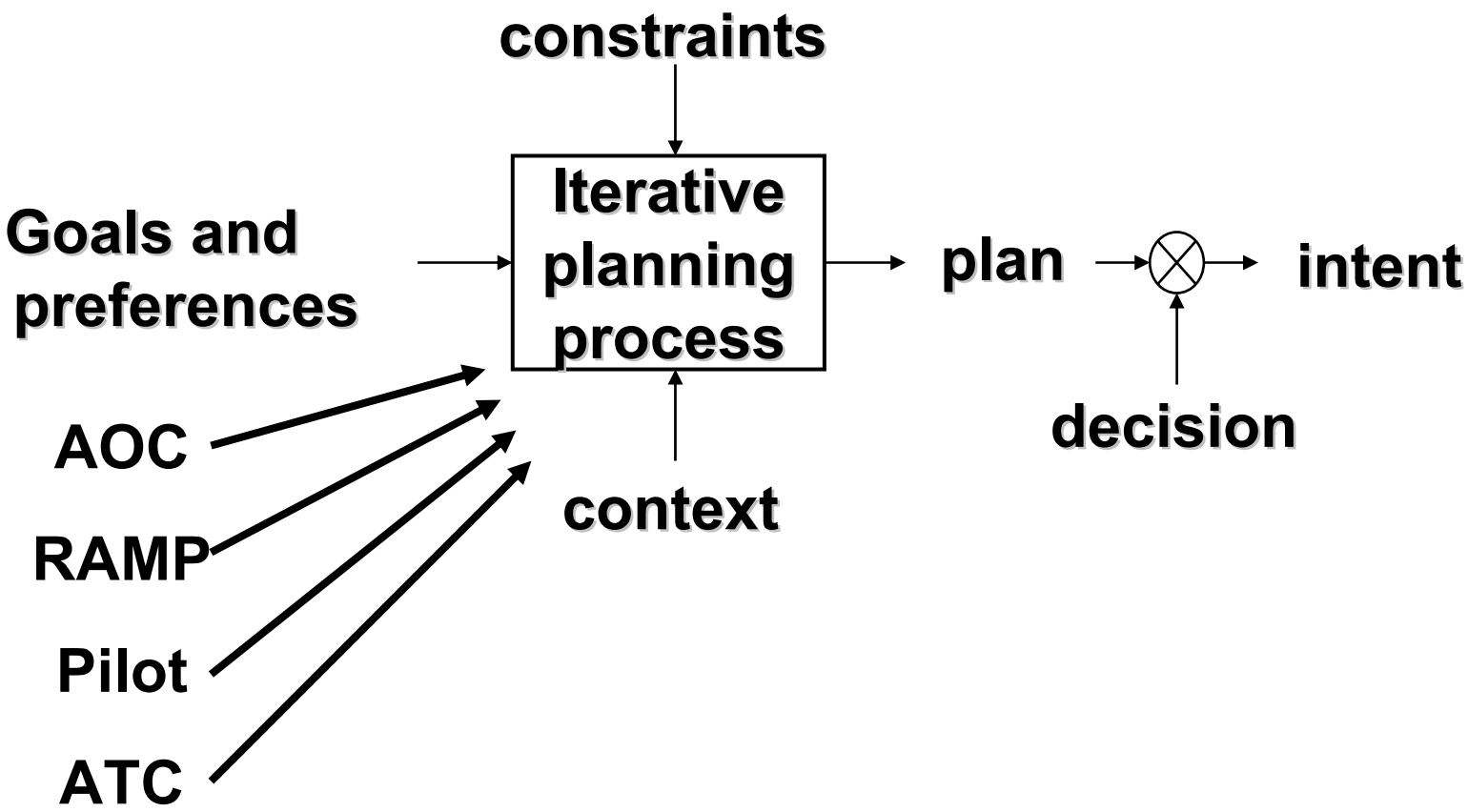
Flight Intent - the future aircraft trajectory expressed as a 4-D profile until destination

Pilot Intent - What the pilot is going to do independent of aircraft systems

ATC Intent - Controller instructions/clearances


Pilot Preferred Trajectory
Aircraft Intended Trajectory
Requests
Aircraft Displays
Air Traffic Controller
Pilot
Aircraft
Control Through Clearances
Control Through Commands
Aircraft Cleared Trajectory
Pilot Intended Trajectory

Intent Generation Process



Today's Intent

- Expectation of future behavior
  - Exchange of data or observed by actors
- Uncertainties occur:
  - Making decisions with stale data
  - Too rapid delivery of data to be processed by actors
  - One sided decisions - no sharing of intent (or reference?)

Future Concept

- Goal - common situational awareness between flight deck, automation and controller.
- Implementation
  - **Flight object - captures preferences (e.g., altitude, runway & gate)**
  - **Exchange of information via voice, data link or broadcast**
  - **Shared expectation, direct verification of compliance**

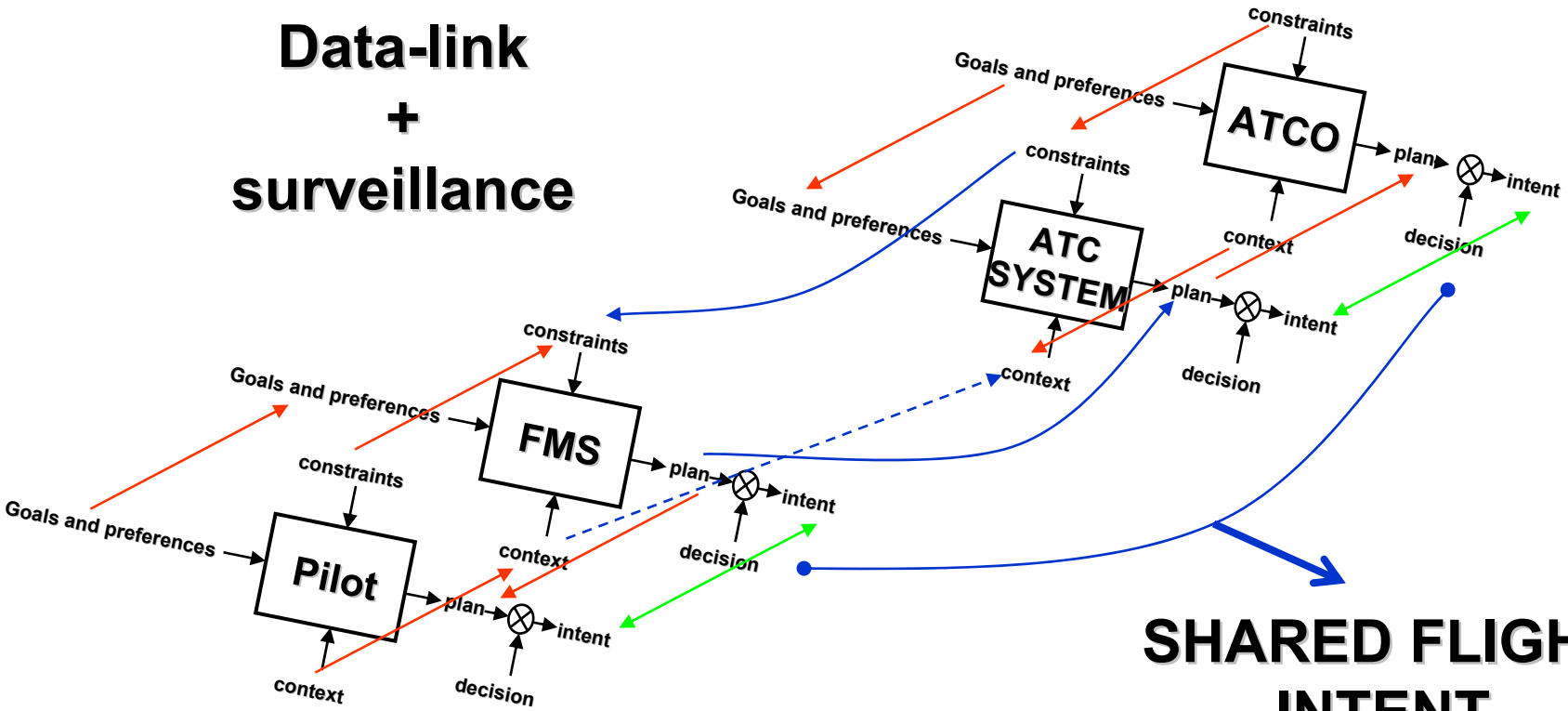
Future Concept - Tactical

- Timeframe is present (current aircraft position and performance) to less than 5 minutes into the future (intended trajectory).

Future Concept - Strategic

- Timeframe is from 5 minutes (intent trajectory) to 30-90 minutes - although the flow time can extend into strategic flow at times of high volume to individual markets.
- The timeframe for TFM is from as little as 30 minutes to 24 hours.

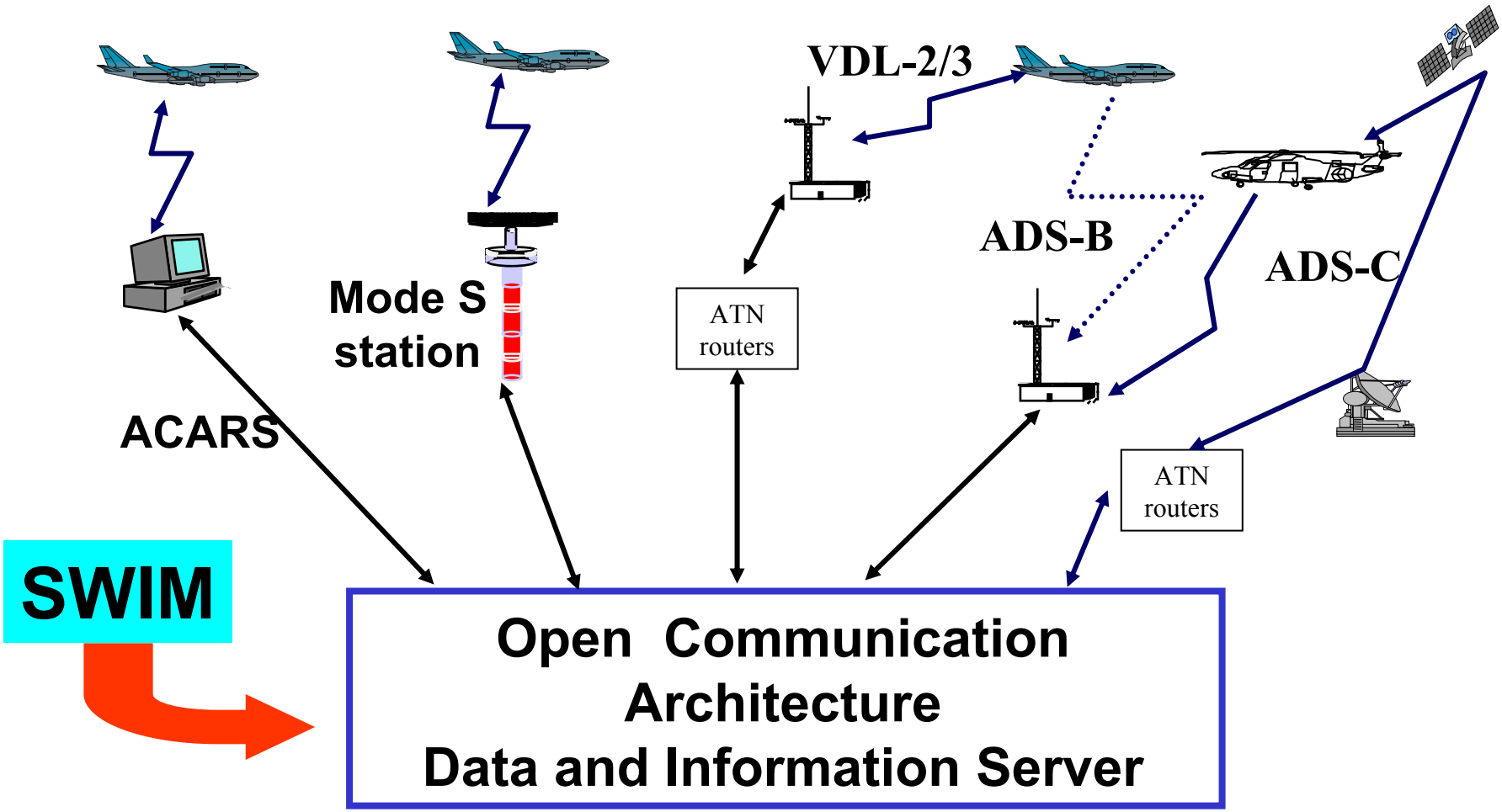
Data-link + surveillance



SHARED FLIGHT INTENT

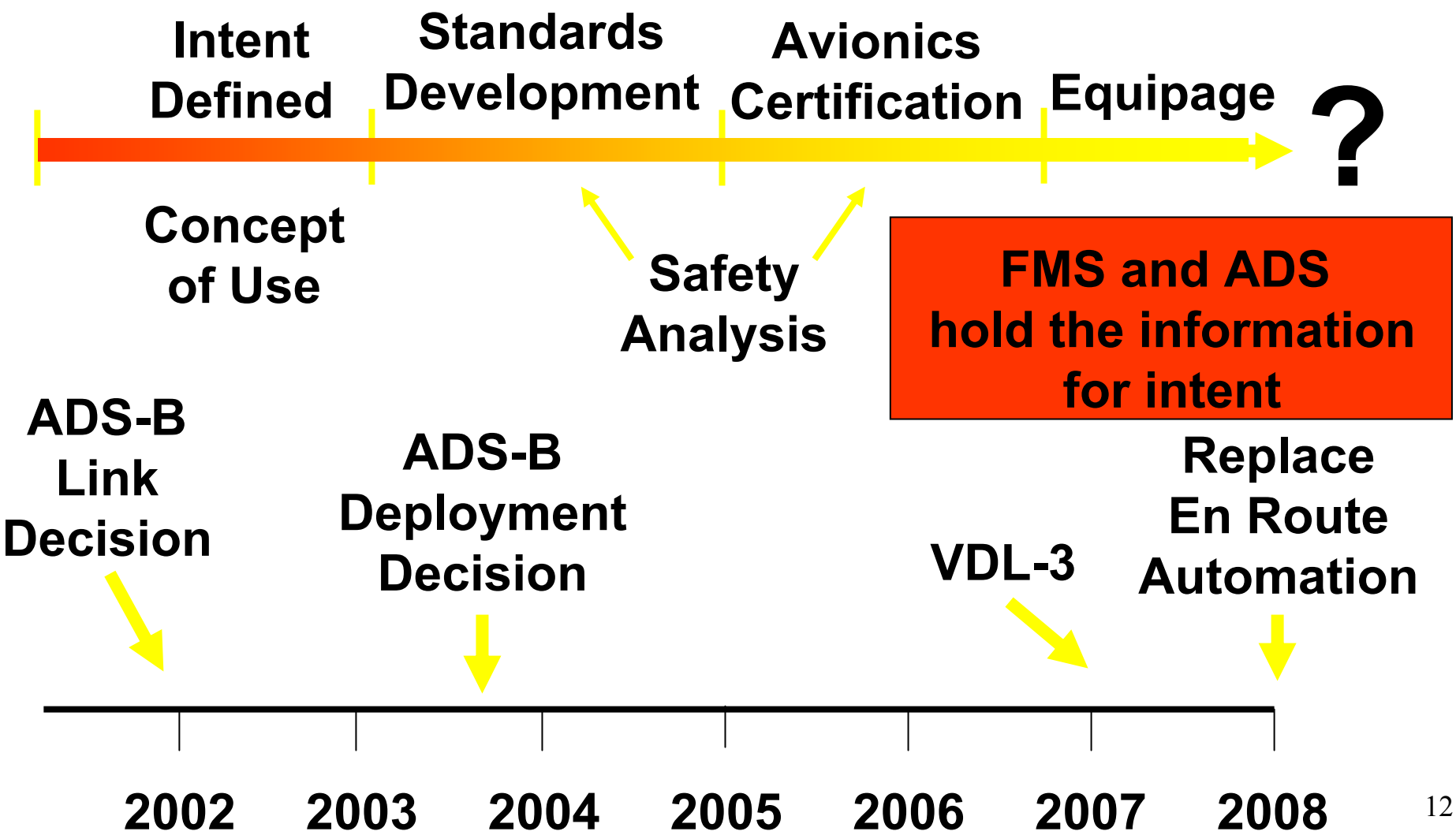
From: Wim Post, National Aerospace Laboratory (NLR)

Information Standardization Now



Define the Intent Message(s) Now

Too Many Messages in Too Many Formats With Too Little Time



Information Standardization Now

- **ADS-B message contains (in current MASPS)**
  - **Turn indicator**
  - **Horizontal velocity vector**
  - **Altitude change rate**
  - **Intended maneuver end can be derived from TCP (Trajectory Change Point)**
    - Intended end of turn, or destination heading
    - Intended level-off altitude at end of climb/descent
- **Also useful to have in ADS-B message:**
  - Turn rate **(for track accuracy improvement)**

Information Standardization Now

- **There are about 25 different FMS's**
  - **Each has different set of outputs**
  - **Output data is typically defined by the OEM (e.g. Boeing or Airbus)**
  - **There are hundreds of output parameters with various rates**
- **The outputs have a hard-coded definition**
  - **Changes involve operating software**
  - **Cannot be modified by loading tables**
- **There are hundreds of FMS functions**
- **Airlines use the FMS in different ways**
  - **For AOC Datalink, there are 38 user-selectable options and more than 12 user-defined parameter values**

- **Current FMS Outputs**
  - General Bus
  - EFIS (Map) Bus
  - ACARS Buses (Airline/ATC)
- **MCDU Flight Plan Pages**
  - Each Waypoint:
    - Identifier
    - Location (Lat/Lon)
    - Constraints (Speed/Altitude/Time)
    - Performance Predictions (Speed/Altitude/Time)
  - Leg Courses/Distances
  - Procedure/Airway Identifiers
- **Map Display Data**
  - Waypoint Position
  - Vectors
  - Leg Transitions/Turn Points
  - Vertical Reference Points (e.g. Top-of-Climb, Top-of-Descent)

FMS General Bus Outputs

- **Periodic Data (Rates vary between parameters: 1 Hz to 20 Hz)**
  - Active Waypoint Position (Lat/Lon)
  - Current Targets: Speed/Mach/Altitude/Vertical Speed/ Track/Heading
  - Current Cruise Altitude
  - Current Bearing-to-Waypoint
  - Current Distance-to-Waypoint
  - Current Roll/Pitch Commands
  - Current Pressure Altitude
  - Current True Airspeed/Ground Speed
  - Vmin/Vmax
  - Predicted Time to Top-of-Climb/Top-of-Descent
  - Next Cruise Flight Level
  - Top-of-Cruise Flight Level
  - Preselected Speed/Mach for Next Flight Phase
  - Plus others...

FMS EFIS (Map) Bus Outputs

- **Periodic Data (Rates vary between parameters: 1 Hz to 20 Hz)**
  - FMS Present Position (Lat/Lon)
  - GPS Autonomous Position (Lat/Lon)
  - Current Position Uncertainty/RNP
  - Current Desired Track
  - Current Cross-Track (Lateral Path) Deviation
  - Current Flight Path Angle
  - Current Ground Speed
  - Current Vertical Path Deviation (Descent)
  - Current Track Angle (True/Mag)
  - Current True Heading
  - Current Wind Speed/Direction/Drift Angle
  - Active Waypoint Identifier
  - Predicted Range-to-Altitude
  - Predicted Time-to-Go to Waypoint
  - Predicted Time-to-Go to Destination
  - Predicted ETA at Destination

FMS ACARS Bus Outputs (Airline-Related)

- **Periodic Data (1 Hz rate)**
  - ETA at Destination
  - Present Position (Lat/Lon)
  - Current Wind Speed/Direction
  - Active Waypoint Ident
  - Current Pressure Altitude
  - Current Roll Angle
  - Alternate Destination Airport Identifier
  - Plus Others...

FMS ACARS Bus Outputs (ATC-Related)

- **Periodic Data (1 Hz rate)**
  - ETA at Destination
  - Gross Weight/ZFW/Fuel Quantity
  - Selected Heading/Track/Altitude/Airspeed/Mach/Vertical Speed
  - Calibrated Airspeed/True Airspeed/Ground Speed/Mach
  - Saturated Air Temperature
  - Present Position (Lat/Lon)
  - True Track/Heading
  - Wind Speed/Direction
  - Roll Angle
  - Current Altitude
  - Active Waypoint Identifier
  - Current Inertial Vertical Speed
  - Plus others...

FMS ACARS Bus Outputs (ATC) - cont'd

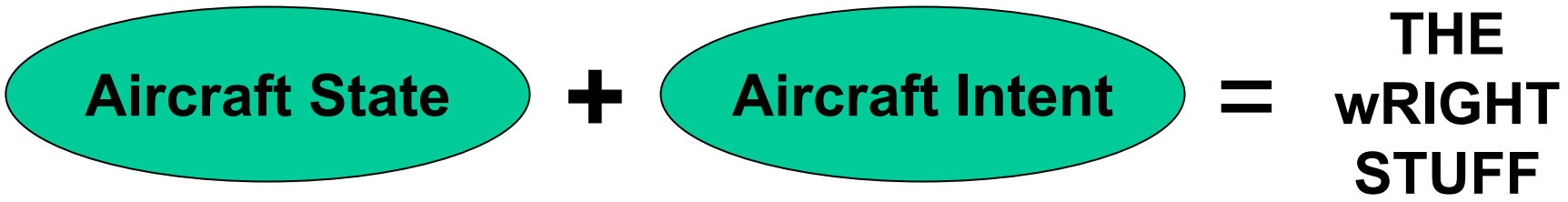
- **FANS1 ADS Message Reports (ARINC 745)**
  - Basic Data
    - Current Position (Lat/Lon)/Altitude/Navigation Figure-of-Merit
    - Time Stamp
  - Flight ID
  - Airframe ID
  - Earth Reference Data
    - Current True Track/Ground Speed/Vertical Speed
  - Air Reference Data
    - Current True Heading/Mach/Vertical Speed
  - Meteorological Data
    - Current Wind Speed/Wind Direction/Temperature
  - Predicted Route Data
    - Predicted Position (Lat/Lon)/Altitude/Time-to-Go for Next Waypoint
    - Predicted Position (Lat/Lon)/Altitude for Next +1 Waypoint

FMS ACARS Bus Outputs (ATC) - cont'd

- **FANS1 ADS Message Reports - Aircraft Intent Data**
  - Fixed Projected Point (FPP): Predicted aircraft position in X minutes
    - X is uplinked by ATC
    - Downlinked for the FPP:
      - Predicted Position (Lat/Lon)
      - Predicted Altitude
  - Intermediate Projected Point (IPP): Any point between aircraft and a given FPP where a change to Altitude, Track, or Speed is predicted
    - Currently the FMS is required to compute up to 10 IPPs
    - Downlinked for each IPP:
      - Predicted Distance from previous IPP
      - Predicted True Track from previous IPP
      - Predicted Time-to-Go from aircraft present position
      - Predicted Altitude at IPP

Leadership Actions Required

- End discussions on defining intent
- Convene/direct standards groups to reach a common message set for trajectory management from FMS's <u>AND</u> ADS-A,B,C



- Standards and Requirements no later than 2004 so that communications and automation development can lead to trajectory-based separation and improved ATM tools

Commemorate Orville and Wilbur with a significant shift in ATC/ATM